

WBS Dictionary as of 9/21/02
Run IIb Silicon Schedule

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-----|-----------------|---------|---------|-------------|-------------|-------------|--------------|
| 1.1 | Run IIb Silicon | 10/2/00 | 7/22/05 | \$7,146,747 | \$1,041,673 | \$3,909,020 | \$12,097,439 |

Notes

WBS Definition-

This summary task covers the effort to develop, build, test, and install the silicon tracker for the D0 Run 2b upgrade project. The detector will replace the existing silicon microstrip tracker currently in use for Run 2a, and will enable operations up to integrated luminosities of 15 pb⁻¹ or more.

Design Parameters

| | | # Sensors in z | # Sensors Total | Sensor Width | Readout Pitch | # Readout in z | # Chips per Readout | Chips Total | # Hybrids Total | | |
|-------|------|-------------------|--------------------|-----------------|------------------|-------------------|------------------------|----------------|--------------------|------|-----|
| Layer | Nphi | R(mm) Axial | R(mm) Stereo | (mm) | (μm) | | | | | | |
| 0A | 12 | 17.95 | -- | 12 | 72 | 15.50 | 50 | 12 | 2 | 144 | 72 |
| 0B | 12 | 24.80 | -- | 12 | 72 | 15.50 | 50 | 12 | 2 | 144 | 72 |
| 1A | 12 | 34.75 | -- | 12 | 72 | 24.97 | 58 | 12 | 3 | 216 | 36 |
| 1B | 12 | 39.00 | -- | 12 | 72 | 24.97 | 58 | 12 | 3 | 216 | 36 |
| 2A | 12 | 54.57 | 57.43 | 12 | 144 | 40.34 | 60 | 8 | 5 | 480 | 48 |
| 2B | 12 | 70.04 | 72.90 | 12 | 144 | 40.34 | 60 | 8 | 5 | 480 | 48 |
| 3A | 18 | 89.45 | 86.59 | 12 | 216 | 40.34 | 60 | 8 | 5 | 720 | 72 |
| 3B | 18 | 103.67 | 100.81 | 12 | 216 | 40.34 | 60 | 8 | 5 | 720 | 72 |
| 4A | 24 | 116.52 | 119.38 | 12 | 288 | 40.34 | 60 | 8 | 5 | 960 | 96 |
| 4B | 24 | 130.48 | 133.35 | 12 | 288 | 40.34 | 60 | 8 | 5 | 960 | 96 |
| 5A | 30 | 148.83 | 145.97 | 12 | 360 | 40.34 | 60 | 8 | 5 | 1200 | 120 |
| 5B | 30 | 162.75 | 159.75 | 12 | 360 | 40.34 | 60 | 8 | 5 | 1200 | 120 |
| Total | | | | | 2304 | | | | | 7440 | 888 |

| | | | | | | | |
|-------|---------|---------|---------|-------------|-----------|----------|-------------|
| 1.1.1 | Sensors | 10/2/00 | 7/28/04 | \$2,272,126 | \$233,777 | \$50,720 | \$2,556,623 |
|-------|---------|---------|---------|-------------|-----------|----------|-------------|

Notes

WBS Definition-

This summary element includes the development and procurement of commercial silicon sensors for all layers of the detector, as well as the setup of detector probing stations, sensor probing and acceptance testing, radiation testing, and vendor qualification and monitoring. There are 3 sensor types in D0 Run 2b silicon detector - L0, L1 and L2. L0 and L1 have the most stringent constraints in terms of the radiation hardness.

Risk Mitigation-

The technical and scope sensor risks are low because we are using single-sided sensors and prototypes have been built which satisfy our requirements. The sensor cost is a significant fraction of the budget so it has a large cost impact, but the probability of the cost going up is very small as we have a quote. The sensors have to be delivered on time or there will be a schedule slippage. Currently, the sensor delivery is not driving the schedule and there are a few months of slack. Schedules by Hamamatsu and their reputation allows us to assign a low probability of the schedule slippage.

| | | | | | | | |
|-------|----------------|---------|---------|-------------|-----------|-------------|-------------|
| 1.1.2 | Readout System | 10/1/01 | 5/18/05 | \$3,754,068 | \$474,447 | \$1,190,659 | \$5,419,174 |
|-------|----------------|---------|---------|-------------|-----------|-------------|-------------|

Notes

WBS Definition-

This summary element includes the development, procurement, and testing of SVX4 readout chips, readout hybrids, cabling, junction cards, test cards, adaptor cards, interface boards, and power supplies, as well as improvements to selected elements of the front-end DAQ system.

Risk Mitigation-

Items with significant risk included in the readout electronics are:

SVX4 chips and the Analog Flex Cables. The project crucially depends on the timely operation of the SVX4 chip. Please see the appropriate summary task for a more detailed description of these two items.

| | | | | | | | |
|-------|-----------------------------------|---------|----------|-----------|-----------|-----------|-------------|
| 1.1.3 | Mechanical Design and Fabrication | 10/1/01 | 12/22/04 | \$349,224 | \$299,949 | \$524,012 | \$1,173,185 |
|-------|-----------------------------------|---------|----------|-----------|-----------|-----------|-------------|

Notes

WBS Definition-

This summary element includes the development and fabrication of assembly fixtures, tooling, and support structures for sensors, readout components, and the fully assembled detector. Also included are mechanical and electrical infrastructure items such as mounting hardware, a detector cooling system, a dry-gas purge system, and equipment protection interlocks and detector status monitoring equipment.

M&S BOE-

Costs are broken down in detail on each line's task.

For the contingency:

L0/L1 structures have specific contingency assumptions included in the cost book. The rest of these tasks have 100% contingency assumed because it is for parts production and fixturing. There is enough risk involved in not having finalized designs and having to make special orders that we've included this 100% contingency.

Labor BOE-

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|--|---|----------------|----------------|------------------|-----------------|--------------------|--------------------|
| "Mechanical Design and Fabrication" continued | | | | | | | |
| | <u>Notes</u> The labor contingency is set nominally to 50% for the carbon tasks done at Fermilab. For the L0/L1 integration by Fermilab, it is set to 100% to account for the lack of D0 experience in making these structures. The University of Washington contingency is described in detail in the cost book. | | | | | | |
| 1.1.4 | Detector Production and Testing | 10/2/00 | 3/25/05 | \$184,452 | \$0 | \$851,639 | \$1,036,090 |
| | <u>Notes</u> WBS Definition- This summary element includes the hardware and software used in testing and quality assurance activities associated with silicon sensor, hybrid, and detector module production. It includes test stands/stations, storage boxes, commercial diagnostic and database software for recording test results. M&S BOE- Costs are listed per line. There are: 1. module boxes costs with contingency of 50% based on guidelines 2. Fixture costs with contingency of 100% because there are not detailed designs existing 3. Epoxy costs with contingency of 100% because we are still looking towards a vendor to provide the necessary glues Labor BOE- There is a flat contingency of 50% put on all labor except for the L2-L5 module and stave production tasks. Here there is a 100% contingency placed. This is based on experience from Run2a module and stave assembly where we ended up using another 0.5 shift of the technicians. They receive time and a half pay so that we need at least 75% contingency for this. We've also assumed another 25% on top of that for safety. | | | | | | |
| 1.1.5 | Silicon Barrel Assembly | 9/3/02 | 7/22/05 | \$383,662 | \$0 | \$1,100,022 | \$1,483,684 |
| | <u>Notes</u> WBS Definition- The summary task that includes designing, prototyping, and production of all cylinders and support structures, the cooling and dry gas systems, as well as the assembly of the L0/L1 modules onto their support structures and testing, and the assembly and testing of staves into the structure. Risk Mitigation- The tasks in this group include the final assembly of the North and South Barrels. This is done at the end of the project and has significant schedule and technical risks which are described in the summary tasks for those operations. | | | | | | |
| 1.1.6 | Monitoring | 10/1/02 | 7/12/04 | \$34,225 | \$21,000 | \$31,712 | \$86,937 |
| | <u>Notes</u> WBS Definition- This summary element includes design, production and testing of radiation and temperature monitoring systems independent of DAQ readout chain M&S BOE- Costs are described in detail on the lines they appear. The contingency for this entire task is set to 50% based on previous experience building these devices. Labor BOE- The contingency is set to a flat 50% both for physicists and technical staff for all tasks. Risk Mitigation- The risks with having these systems not work are minimal. | | | | | | |
| 1.1.7 | Software and Simulation | 4/16/01 | 5/5/05 | \$2,500 | \$12,500 | \$0 | \$15,000 |
| | <u>Notes</u> WBS Definition- This summary element refers to the software development needed for the design and commissioning of the Run IIb silicon tracker. It includes the simulation studies to justify our design, the development of codes required for silicon data analysis, calibration and monitoring and the associated design of a new hardware database. M&S BOE- There are costs associated with the production database that are described in that task. There is no contingency taken on this cost as it is fixed by an MRI grant. Labor BOE- All tasks are handled by physicists in this summary task except for the production database task that is costed as M&S. The detailed description resides on each line on how the physicist cost was determined. The contingency for physicists is placed at 100% for all of these tasks to account for the vagaries of predicting how much work it will take to get the codes running. Risk Mitigation- No items appear above the cutoff, but this summary task is crucial to running of the detector during the commissioning stage and that is why these items appear in our schedule early. | | | | | | |

WBS Dictionary as of 9/21/02
Run IIb Silicon Schedule

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-------|---|---------|--------|-----------|-----------|------------|------------|
| 1.1.8 | Administration | 10/1/01 | 6/2/05 | \$166,490 | \$0 | \$160,256 | \$326,746 |
| | <i>Notes</i> WBS Definition- The summary task associated with administration of the silicon project including management, travel, shipping, purchasing support, technical support, and software licenses including both the R&D and project phases. M&S BOE- The cost BOEs are listed per item. The contingency is 50% for all project related items and 30% on the R&D phase which is nearing completion. Labor BOE- The contingency for all tasks is 50%. Physicist contingency is assigned 50% | | | | | | |

WBS Dictionary as of 9/21/02
Run IIb Trigger

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-------|---|----------|---------|-------------|-------------|------------|-------------|
| 1.2 | Run IIb Trigger Upgrade | 11/1/01 | 3/16/05 | \$1,429,918 | \$1,308,600 | \$98,203 | \$2,836,721 |
| | <u>Notes</u> WBS Definition- The Level 1 trigger upgrade is designed to allow us to maintain the peak output rate of 5 kHz at the higher luminosities of Run 2b. This will be accomplished by upgrades to three systems - the Level 1 calorimeter trigger, a calorimeter cluster track match at Level 1, and the Level 1 central track trigger. Procurement of additional Level 2 beta processors, silicon track trigger electronics boards, associated hardware, and firmware support is also included in the trigger upgrade project, as is the simulation effort. This summary WBS element includes all the effort required to develop, build, test, install, and initially commission these trigger elements. | | | | | | |
| 1.2.1 | Level 1 Calorimeter Trigger | 1/2/02 | 2/7/05 | \$456,521 | \$921,727 | \$6,680 | \$1,384,928 |
| | <u>Notes</u> WBS Definition- This summary element covers the Level 1 calorimeter trigger modifications. It includes development and procurement of ADC/digital filter boards (ADF), development and procurement of trigger-algorithm boards (TAB), the provision of output signals to facilitate a match between calorimeter towers and tracks, and procurement and improvements in associated readout crates, power supplies, cabling, and controls hardware. | | | | | | |
| 1.2.2 | Level 1 Calorimeter Track Matching | 8/1/02 | 7/14/04 | \$177,504 | \$40,560 | \$30,080 | \$248,144 |
| | <u>Notes</u> WBS Definition- This summary element provides for improvements in the Run2a track-matching trigger. It includes development and procurement of slightly modified versions of existing Level 1 muon cards, and procurement of related cabling, connectors, readout crates, processors, and power supplies. | | | | | | |
| 1.2.3 | Level 1 Tracking | 11/12/02 | 3/16/05 | \$569,208 | \$242,995 | \$57,980 | \$870,183 |
| | <u>Notes</u> WBS Definition- This summary element provides for improvements in the existing track trigger. It includes design and development of algorithms that utilize larger FPGAs, and development and procurement of new Digital Front-End (DFE) boards that utilize these FPGAs. | | | | | | |
| 1.2.4 | Level 2 Beta Processor | 12/1/03 | 2/28/05 | \$48,950 | \$44,466 | \$0 | \$93,416 |
| | <u>Notes</u> WBS Definition- This summary element includes the procurement of additional single-board computers (Level 2 Beta processors), associated hardware, and firmware support. | | | | | | |
| 1.2.5 | Silicon Track Trigger Upgrade | 12/2/02 | 2/28/05 | \$172,235 | \$58,852 | \$3,463 | \$234,550 |
| | <u>Notes</u> WBS Definition- This summary element includes upgrades to the Run 2a silicon track trigger to adapt it to the increased number of inputs from the Run 2b silicon detector. It consists of the procurement of additional electronics boards of the Run 2a type. Also included are firmware changes, and additional cabling and connector hardware. | | | | | | |
| 1.2.6 | Trigger Simulation | 11/1/01 | 3/5/04 | \$0 | \$0 | \$0 | \$0 |
| | <u>Notes</u> WBS Definition - This summary task described the simulation tasks that are needed to design and optimize the trigger while it is being developed, and afterwards to provide standard tools for simulating the behavior of the as-built system. | | | | | | |
| 1.2.7 | Administration | 10/1/02 | 3/8/05 | \$5,500 | \$0 | \$0 | \$5,500 |
| | <u>Notes</u> WBS Definition- The summary task associated with administration of the trigger upgrade project including management, travel, shipping, purchasing support, technical support, and software licenses including both the R&D and project phases. M&S BOE- The cost BOEs are listed per item. The contingency is 50% for all project related items and 30% on the R&D phase which is nearing completion. Labor BOE- The contingency for all tasks is 50%. Physicist contingency is assigned 50% | | | | | | |

WBS Dictionary as of 9/21/02
Run IIb Online/DAQ

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-------|---|---------|---------|--------------|-----------|--------------|--------------|
| 1.3 | Online Systems | 1/2/02 | 10/4/05 | \$605,000.00 | \$0.00 | \$178,976.00 | \$783,976.00 |
| | <u>Notes</u> WBS Definition- This summary WBS element includes upgrades associated with data-taking and detector monitoring and controls systems. We have set a goal for data-logging of 100 Hz in the higher luminosity environment of Run 2b. This element describes the resources needed to develop an online system that will meet the physics needs of the experiment. | | | | | | |
| 1.3.1 | Level 3 Systems | 1/2/02 | 9/29/05 | \$210,000.00 | \$0.00 | \$1,128.00 | \$211,128.00 |
| | <u>Notes</u> WBS Definition- Summary task for operations involving acquisition of Linux systems. Includes DAQ Readout SBC and Level 3 nodes. Risk Mitigation- The cost impact results from a possible need to purchase more Level 3 filter farm nodes in order to meet the processing requirements of the L3 software trigger. The 70% contingency on the node procurement task wbs 1.3.1.2.3 is set large enough to enable almost a doubling of the purchase. If in a situation where this might be needed, a software effort to reduce the per-event processing time could additionally be mounted. | | | | | | |
| 1.3.2 | Network and Host Systems | 1/2/02 | 10/4/05 | \$247,000.00 | \$0.00 | \$135,548.00 | \$382,548.00 |
| | <u>Notes</u> WBS Definition- Summary task for operations involving acquisition of Network and Host systems. Includes DAQ, Database, File Server, Control Room, and Monitor nodes. | | | | | | |
| 1.3.3 | Control Systems | 1/2/02 | 9/29/05 | \$148,000.00 | \$0.00 | \$28,294.00 | \$176,294.00 |
| | <u>Notes</u> WBS Definition- Summary task-Operation and maintenance of Control System components | | | | | | |
| 1.3.4 | DAQ/Online Management | 10/1/02 | 9/30/05 | \$0.00 | \$0.00 | \$14,006.00 | \$14,006.00 |
| | <u>Notes</u> WBS Definition- Summary task for subproject management tasks | | | | | | |

WBS Dictionary as of 9/21/02
Run IIb Project Administration

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-------|--|---------|---------|--------|-----------|--------------|--------------|
| 1.4 | Run IIb Project Administration | 10/1/02 | 9/30/05 | \$0.00 | \$0.00 | \$780,760.00 | \$869,760.00 |
| | <i>Notes</i> WBS Definition- This summary task covers the overall effort to administer, manage, and direct the project as a whole. It includes project-office administrative support and tasks related to project budgeting, scheduling, reporting, and preparation for reviews. Travel for project office personnel and other travel that is not covered by individual subproject budgets is also included. | | | | | | |
| 1.4.1 | FY03 | 10/1/02 | 9/30/03 | \$0.00 | \$0.00 | \$259,904.00 | \$290,904.00 |
| | <i>Notes</i> WBS Definition- FY03 administrative effort | | | | | | |
| 1.4.2 | FY04 | 10/1/03 | 9/30/04 | \$0.00 | \$0.00 | \$260,952.00 | \$289,952.00 |
| | <i>Notes</i> WBS Definition- FY04 administrative effort | | | | | | |
| 1.4.3 | FY05 | 10/1/04 | 9/30/05 | \$0.00 | \$0.00 | \$259,904.00 | \$288,904.00 |
| | <i>Notes</i> WBS Definition- FY04 administrative effort | | | | | | |

WBS Dictionary as of 9/21/02
Run IIb Installation

| WBS | Name | Start | Finish | M&S EQ | M&S Labor | FNAL Labor | Total Cost |
|-------|---|----------|----------|-------------|-----------|--------------|--------------|
| 1.5 | Run IIb Installation | 5/7/04 | 12/22/05 | \$82,200.00 | \$0.00 | \$537,019.32 | \$619,219.32 |
| | <u>Notes</u> WBS Definition- This summary task has as its scope the removal of the Run IIa silicon tracker from the D0 detector, the installation of the Run IIb silicon tracker system, the installation of the L1 Calorimeter tracking trigger, the L1 Calorimeter track matching system, upgrades to the Level 2 beta processors, the L2 silicon track trigger upgrade, and the technical commissioning of all the new systems prior to the closing of the detector and the restart of the colliding beam program. | | | | | | |
| 1.5.1 | Run IIb Silicon Installation | 5/7/04 | 12/22/05 | \$42,200.00 | \$0.00 | \$392,627.74 | \$434,827.74 |
| | <u>Notes</u> WBS Definition- This summary task covers the effort to install the silicon tracker for the D0 Run IIb upgrade project. The detector will replace the existing silicon microstrip tracker currently in use for Run 2a, and will enable operations up to integrated luminosities of 15 pb ⁻¹ or more. | | | | | | |
| 1.5.2 | Run IIb Trigger Installation | 6/7/04 | 12/20/05 | \$40,000.00 | \$0.00 | \$144,391.58 | \$184,391.58 |
| | <u>Notes</u> WBS Definition- The Run IIb trigger upgrade includes upgrades to three systems - the Level 1 calorimeter trigger, a calorimeter cluster track match at Level 1, and the Level 1 central track trigger, as well as upgrades to the Level 2 beta processors and the Level 2 Silicon Track Trigger. This summary WBS element includes the effort required to install and initially commission these trigger upgrades. | | | | | | |
| 1.5.3 | Run IIb Detector Ready for Beam | 12/22/05 | 12/22/05 | \$0.00 | \$0.00 | \$0.00 | \$0.00 |
| | <u>Notes</u> WBS Definition Milestone-Run IIb Detector is ready for beam. | | | | | | |